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14. ABSTRACT
This final report documents support from ONR in developing a solid state single molecule sensor. The sensor uses a voltage biased nanopore in an insulating membrane that separates two pools of conducting salt water. The biased nanopore attracts and translocates charged biopolymers like DNA. The ionic current that flows through the pore is sensitive to the presence of single molecules and can be used to measure their passage. In this work we demonstrate the process using solid state pores for the first time.

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Nanopore, DNA, Sensors, Biopolymers

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FINAL REPORT

GRANT #: N00014-01-1-0788

PRINCIPAL INVESTIGATOR: Prof. Jene A. Golovchenko

INSTITUTION: President and Fellows of Harvard College

GRANT TITLE: Electrical Properties of Solid-State Nanopore Sensors

AWARD PERIOD: 17 April 2001 - 31 August 2002

OBJECTIVE: To investigate the problem of developing a solid state nanopore sensor capable of rapidly and electronically detecting and identifying individual polymeric biomolecules (RNA, DNA, proteins etc.) in aqueous environments such as those found in the human body or sea water. The sensor will use ionic conduction and electron tunneling mechanisms to sense individual molecules translocating through a solid state nanopore, and be capable of integration with "on chip" electronics. The major research question is how to articulate the neighborhood of a solid state nanopore to optimize electronic noise, speed, molecular sensitivity, and specificity. Direct electrical read-out of DNA sequence will be used to validate success.

APPROACH: The electrical properties of nanopores are developed to probe and characterize biopolymers, including DNA and RNA. Using focused ion beam and argon ion sculpting facilities we recently developed at Harvard, 1-5 nanometer pores in self supporting silicon nitride and silicon dioxide membranes mounted on silicon chips are fabricated. A nanopore surface treatment chamber is built to investigate the influence of various solid state and chemical treatments on the electronic sensitivity and selectivity of the solid state nanopores. This chamber is also used to articulate the nanopore with metal probes, and molecular tunneling studies are initiated with the metalized nanopores.

ACCOMPLISHMENTS: Under the grant the first solid state nanopores capable of detecting single molecules were fabricated and integrated into an electronic - fluidic system. Single molecules were detected electronically.

CONCLUSIONS: Solid state nanopores will be viable single molecule detectors for observing and characterizing polymer biomolecules.

SIGNIFICANCE: A solid state nanopore in an insulating material represents a fundamental nanoscale device. When fabricated in large scale arrays and integrated with local electronics and smart data processing, nanopores will be capable of providing extraordinary amounts of molecular

level information about the environment. Such sensors will be capable of rapidly identifying agents of biological warfare, and of monitoring and predicting disease in human subjects. This project will also introduce new approaches to fabricating nanostructures with novel electronic properties. Nanopores will have a broad impact on next generation electronics capabilities, where quantum structures will operate at room temperatures.

PATENT INFORMATION: N/A

AWARD INFORMATION: None

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Li, J., D. Stein, C. McMullan, D. Branton, M.J. Aziz, and J.A. Golovchenko. 2001. Ion-beam sculpting at nanometre length scales. Nature 412: 166-169.